Walking the Mesozoic

National Park Service
U.S. Department of the Interior

Dinosaur National Monument

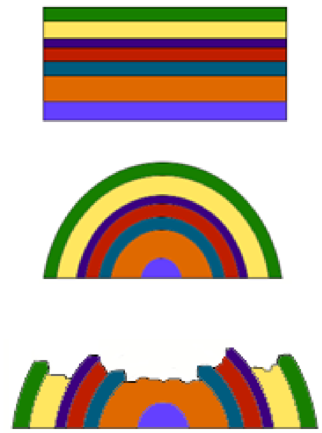
Travel through Time: Sound of Silence Trail

The Mesozoic Era lasted from about 250 million to 65 million years ago. It saw the evolution, terrestrial dominance, and eventual extinction of the dinosaurs. Here at Dinosaur National Monument the well exposed Mesozoic rocks record the amazing story of how life and the land changed over the course of almost 200 million years. This brochure offers a more in depth look at the fossils and geology seen along the Sound of Silence Trail.

Getting Started

For much of the Mesozoic, western North America was hot and dry, and the area around what is now Dinosaur National Monument alternated between desert dunes and broad river plains. The mountains that are here now had not been born, so this area was flat enough to be periodically flooded when sea level rose. Then in the Cretaceous (about 145 million years ago), a chain of volcanoes that had formed out in the Pacific Ocean slammed into North America. Mountains rose, seas were born and erased, and the land bent and broke. The climate turned warm and humid, and the sea advanced, flooding North America down the middle.

The rocks in this part of Dinosaur National Monument are almost all sedimentary. They were created when loose sediment like sand or mud was buried so deep underground that it became rock. Different sediments produce rocks of different strengths; you will be able to see that some layers have resisted erosion and stand up in ridges and cliffs while others are so badly eroded you can't even tell they're rock. Take a look at the figure to the right. The block of horizontal rocks you see at the top gets folded into a shape called an anticline (middle). After a time, the top is eroded away, but the weak rocks erode more than the strong rocks (bottom). That's why there are so many ridges in Dinosaur National Monument. The erosional valleys between the ridges are called strike valleys. Split Mountain, the major topographic feature on the Utah side of the park, is an anticline, just like the one illustrated above. If you were to walk from the outermost layer towards the center, you would be traveling back in time. Taking the Fossil Discovery Trail and the Sound of Silence Trail allows you to do just that.



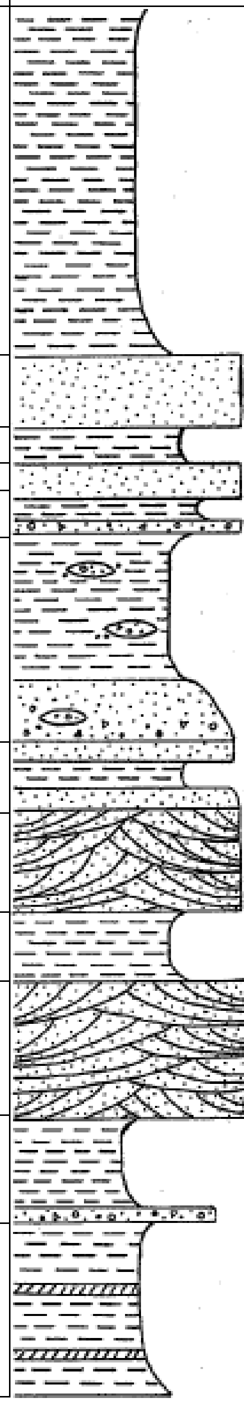
It is possible to walk this section of the tour without having done the Fossil Discovery Trail, although it's preferable to do this part second. If you are beginning with this part, though, know that it begins in the Jurassic, in the famously dinosaur-bone-filled Morrison Formation. Park at the Sound of Silence trailhead, 3.5 miles into the park on the Utah side. Remember that the first rock units you see are the youngest.

The Sound of Silence Trail is one of the best hikes in this area of the park. This guide will not take you through the most strenuous parts of the trail (in fact, the first half of it is largely flat), but even so, this trail is longer and more arduous than the Fossil Discovery Trail. Do bring water and a hat with you, especially if you plan to hike the entire trail. At least two liters are recommended.

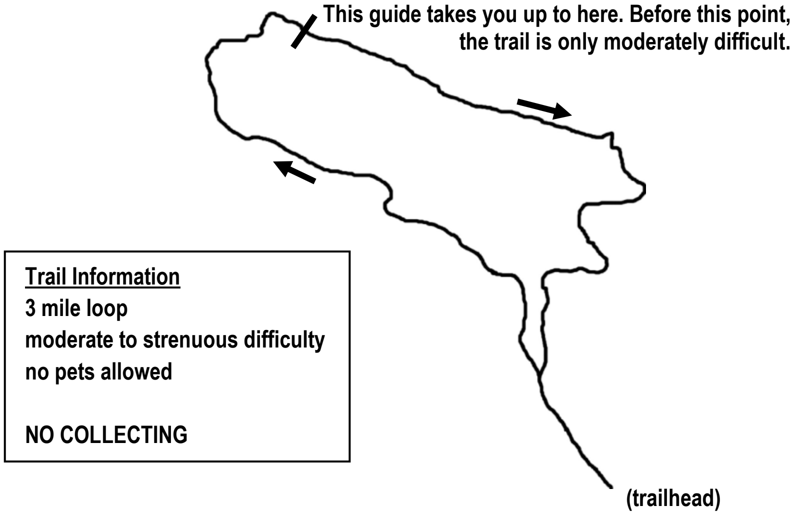
This is called a stratigraphic column. Geologists use it to summarize a set of rock layers: their ages, compositions, and how easily they erode. The oldest layers, the ones that were laid down first, are at the bottom, just as they would be in outcrop (if they hadn't been folded, faulted, or overturned). There are different symbols for different kinds of rock: sandstones are filled in with dots, shales with horizontal dashes, and so on. The farther out to the right a rock unit sticks out, the stronger it is, so those units represent the tall ridges you will see along the trails. Note how the alternation of sandstone and shale reflects the transgressive-regressive sequence discussed on the previous page.

Trail	Period	Rock Unit	Thickness m (ft)	Description
FOSSIL DISCOVERY TRAIL	CRETACEOUS	Mancos Shale	1450-1700 (4800-5600)	Dark grey, silty to clayey, marine shale that weathers light grey to light yellow. Minor siltstone and sandstone in the upper part with layered bentonite (ca. 90 Ma) and a few limestone beds in the lower part. Locally fossiliferous. Top not exposed in DNM.
FOSSIL DISCOVERY TRAIL	CRETACEOUS	Frontier Sandstone	30-90 (100-300)	Brown sandstone, siltstone, and shale, marine fossils, and local coal.
FOSSIL DISCOVERY TRAIL	CRETACEOUS	Mowry Shale	10-65 (33-220)	Hard, grey, fissile, siliceous shale.
FOSSIL DISCOVERY TRAIL	CRETACEOUS	Dakota Sandstone	12-30 (40-100)	Light-grey to –yellow sandstone.
FOSSIL DISCOVERY TRAIL	CRETACEOUS	Cedar Mountain Formation	0-60 (0-200)	Colorful clay- and siltstone, some sandstone. Local conglomerate.
FOSSIL DISCOVERY TRAIL; SOUND OF SILENCE TRAIL	JURASSIC	Morrison Formation	200-300 (650-1000)	Multicolored mud- and siltstone, with bentonite, sandstone, and conglomerate. Dinosaur fossils.
FOSSIL DISCOVERY TRAIL; SOUND OF SILENCE TRAIL	JURASSIC	Stump Formation	21-37 (70-120)	Siltstone and shale over sandstone.
SOUND OF SILENCE TRAIL	JURASSIC	Entrada Sandstone	12-49 (40-160)	Pink to yellow-grey eolian sandstone.
SOUND OF SILENCE TRAIL	JURASSIC	Carmel Formation	0-43 (0-130)	Dark red sandy silt- and mudstone.
SOUND OF SILENCE TRAIL	JURASSIC / TRIASSIC	Glen Canyon Sandstone	180-200 (600-650)	Pink to grey-yellow eolian sandstone.
SOUND OF SILENCE TRAIL	TRIASSIC	Chinle Formation	60-140 (200-460)	Red to grey siltstone, sandstone, and shale with local basal conglomerate.
SOUND OF SILENCE TRAIL	TRIASSIC	Moenkopi Formation	150-240 (500-800)	Mostly red to brown, green, and grey siltstone and shale with thin gypsum beds. Ripple marks, reptile tracks, marine invertebrate fossils.

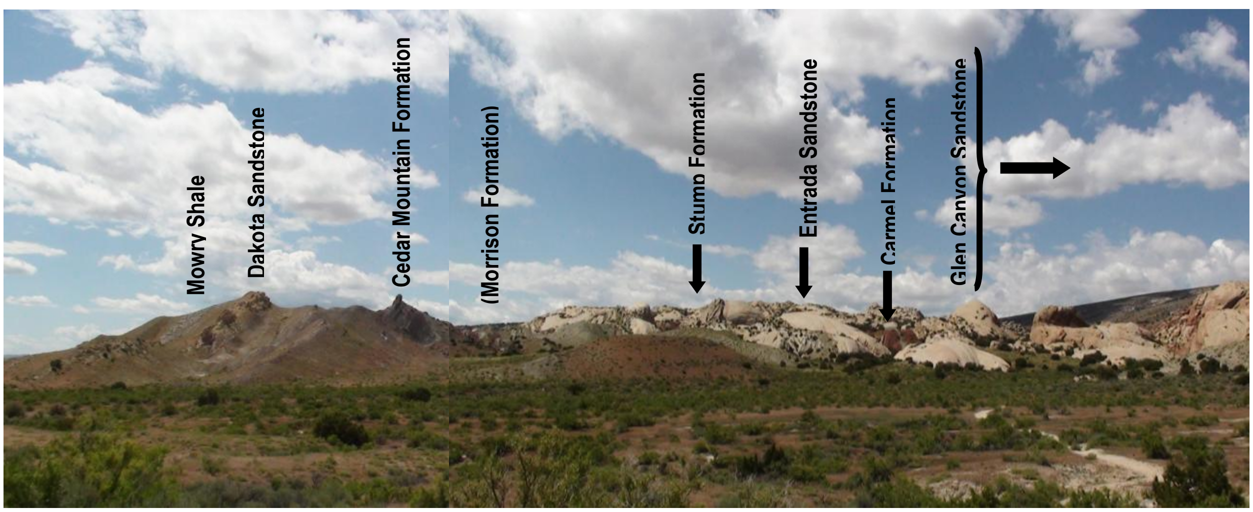
Lithology



Part II: Sound of Silence Trail



Before you begin walking the trail, pause a moment and try to orient yourself. There are outcrops to your left that you might recognize: the Mowry Shale, Dakota Sandstone, and Cedar Mountain/Morrison units. The Morrison is quite difficult to see clearly in this area; don't worry if you can't make it out.

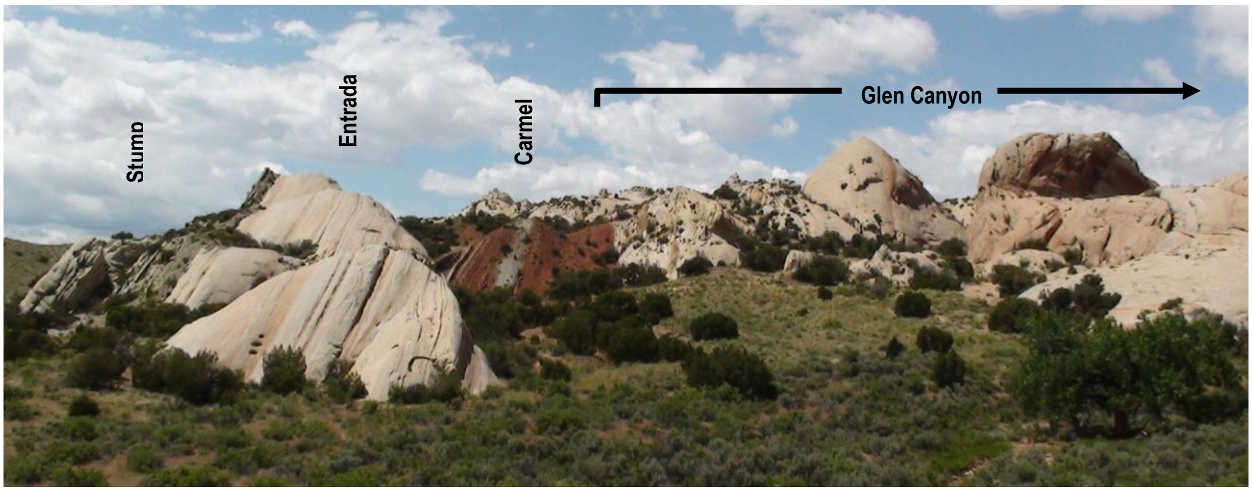


Morrison Formation

Begin walking the trail. You are currently walking over the **Morrison Formation**. The Morrison was deposited in a variety of freshwater settings: lakes, streams, ponds, etc. This formation is one of the most prolific dinosaur-producing layers in the world; Dinosaur National Monument was created in 1915 specifically to protect the Carnegie Quarry, which yielded partial or complete fossil skeletons from about 500 individual dinosaurs of ten different species, crocodiles, freshwater turtles, freshwater mollusks, and petrified wood. There are over 400 Morrison fossil localities in the park. The Morrison extends over one million square kilometers, from Nebraska to Montana to New Mexico.

Stump Formation

The first low (<10 ft) sandstone ridge you pass is part of the Stump Formation. This rock layer was deposited in a Jurassic sea, and in some places contains lots of marine fossils, mostly mollusks, although a complete ichthyosaur skeleton was found in the Stump sandstone outside the park. The Stump contains abundant marine bottom invertebrate fossils, including clams and brachiopods.



Entrada Sandstone

On the next large, rounded outcrop just off the trail to your right, you can see where the end of the Stump—the grey, planar sandstone—meets the **Entrada Sandstone**, which is rounded and yellow with fine red layers. You can also see the contact between the two layers further off the trail to your left (pictured above). The Entrada tends to form very smooth, rounded outcrops. It is the same stone that forms the spectacular arches and spires of Arches National Park in southern Utah.

Carmel Formation

On that same outcrop to your left (best seen from further down the trail), you can see that between the Entrada and the next thick sandstone unit is the **Carmel Formation**, a relatively thin dark red siltstone unit. It is softer than the surrounding rock, and tends to form strike valleys. The Carmel was formed on the bed of a warm, shallow sea, and contains invertebrate fossils and occasional dinosaur footprints.

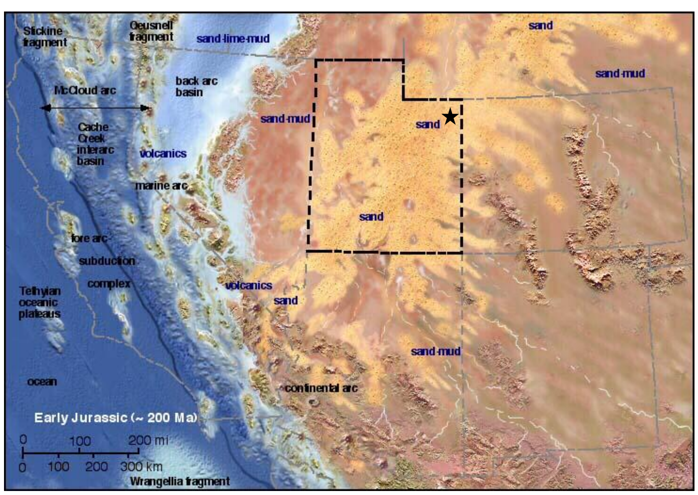
Glen Canyon Sandstone

On the other side of the Carmel Formation is the **Glen Canyon Sandstone**, which happens to look very similar to the Entrada. The best way to tell which formation you're looking at is to locate the Carmel and use it for reference. The Glen Canyon was deposited in an enormous desert with dunes hundreds of meters high. The dunes are what caused the sweeping cross-bedding you can see (shown below). Cross-bedding is formed as the wind pushes a dune across the desert. What you're seeing is the steep side of the dunes, the side away from the wind; the curved layers are preserved when sand is swept off the crest of the dune and rolls down to put a new layer on its side. Cross-bedding can occur with water or wind, but only wind can make cross-beds of this size.

In between the desert dunes were flat, reddish areas, some of which had permanent bodies of water in them! It might seem incredible, but an environment like this actually exists today in Inner Mongolia (see Google Earth image, below). Some of these ponds or lakes were fed by freshwater springs, which we know because of limestone mounds in part of the Glen Canyon. The mounds formed when dissolved minerals precipitated out of the water, making a mound around the source, and we know it was fresh water because there are freshwater snail fossils nearby.

In one area of the Glen Canyon, the lee side of a dune is exposed, and on it are the footprints of hundreds of *Brasilichnium*, small mammal-like reptiles, as well as a small dinosaur footprint and large scorpion tracks. These are probably the record of a single night's activity; there must have been enough dew that night to preserve the tracks long enough for them to be buried and preserved.

Elsewhere, parts of the Glen Canyon are known as the Aztec, the Nugget, or the Navajo. No matter what you call it, this rock layer is responsible for the spectacular rounded and cross-bedded bluffs along this part of the trail. When you get closer to the outcrops, you may notice the pockets in the face of the stone. These are the result of spheres of minerals that precipitated in the loose sand: later, they weathered into protrusions and eventually fell out, leaving behind pockets that were enlarged by wind.

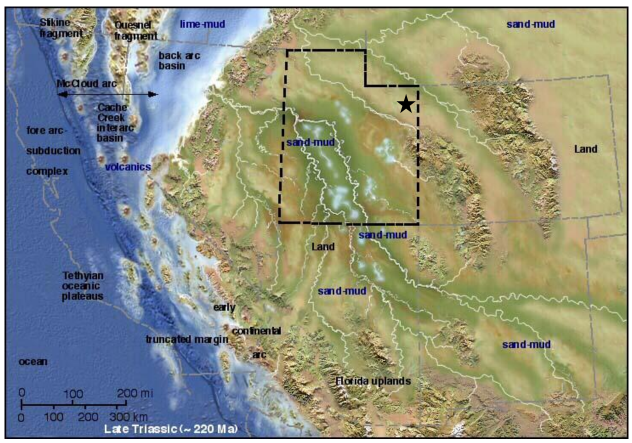


This map shows the desert the Glen Canyon was deposited in.

Chinle Formation

When the trail makes a major curve to the right, you will walk out of the Glen Canyon and into the **Chinle Formation**. The Chinle was deposited in a coastal plain river system, and so the deposits are quite varied depending on where they were deposited. The Chinle is the formation famous for its fossilized plants and animals in Petrified Forest in Arizona, although it doesn't contain quite so many fossils in Dinosaur National Monument. Many bones and bone fragments have been found, however, which indicate a rich variety of reptiles and amphibians. This formation is particularly rich in *trace fossils*, which are fossils that don't include bodies or body parts; for example, burrows and footprints are trace fossils. The Chinle includes burrows and trails of snails, insects, crayfish, and freshwater horseshoe crabs.

Most of the Chinle is siltstone and shale, mostly red and very easily erodible, so you can't always see it very easily. But the bottom of the Chinle is the Gartra Grit, a grey, very coarse sandstone. At one point, Gartra boulders have fallen across the path and you will be able to touch them and feel just how coarse they are, but all around the park, you will be able to see the Gartra because it often forms high grey ridges.



This is the river system where the Chinle was deposited.

Moenkopi Formation

When you pass the Gartra you will find yourself in the **Moenkopi Formation**, a mostly red siltstone/shale unit. It was deposited on a sea bottom. The trail winds through badlands hills, and if you look carefully you might see gypsum beds: they're thin, an inch or two thick, and whitish- to greenish-colored. When you come up out of the hills, you will be able to see how this formation has weathered into a strike valley running parallel to the path on your left. On the other side of the valley, the hills are formed by the massive white Weber Sandstone. Although it was deposited well before the Mesozoic, it is a prominent part of Split Mountain and is worth mentioning. It forms the spectacular cliffs visible from Split Mountain Campground.

You have now passed through the entire Mesozoic section of Dinosaur National Monument. Should you choose to continue on the trial (which is a great hike but will take longer than simply turning around); you will eventually swing back towards the road, crossing directly over ridges of the Gartra Member and the Glen Canyon.

CREDITS

Paleogeographic maps: Ron Blakey (http://jan.ucc.nau.edu/~rcb7/paleogeogwus.html)
All other photos and figures: NPS